Chapter 4
Design Principles for Educational Mixed Reality?
Adaptions of the Design Recommendations of Multimedia Learning

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ABSTRACT

Mixed reality (MR) applications are widely considered to be effective educational tools. However, the use of MR alone cannot ensure learning, and studies even suggest that the affordances of this technology could decrease the mental processes required for the acquisition of new knowledge. Like any other technological innovation, the educational possibilities of MR are closely related to the design of its contents. Despite this, there are no design recommendations for MR focused on learning. Educational psychology presents a range of empirically proven design guidelines for multimedia learning environments. This chapter reviews existing guidelines and categorizes them into principles related to the perception of information and the related essential information processing (design principles) and principles aiming at promoting generative learning (activating principles). These principles are translated to MR-learning environments.

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INTRODUCTION

Mixed reality (MR) has become a fast-developing field of application and research (Dörner et al., 2019; Schmalstieg & Höllerer, 2016), and MR technologies are increasingly used as educational tools. Describing the merging of the real world and virtual elements with the idea to create new and immersive environments, the most applied scheme to understand the range of technologies combined by MR is the "reality–virtuality continuum" (Milgram et al., 1994). The continuous spectrum of this scheme connects the two poles of reality to virtual reality. The area in between the two extremes is defined as MR. Through this range, MR comprises all possible variations of technologies such as augmented reality (AR) and virtual reality (VR) combining real and virtual objects. Moreover, compared to other media, MR has some distinctive characteristics such as immersion and spatiality. Based on the reality–virtuality continuum, this chapter does not refer to one particular technology of MR. Instead, MR refers to a wide spectrum of technologies between the two poles.

The opportunities of MR-based learning environments have been explored in many research reviews (Akçayır & Akçayır, 2017; Chen et al., 2017; Freina & Ott, 2015; Garzón & Acevedo, 2019; Merchant et al., 2014; Radu, 2014; Sommerauer & Müller, 2018). The reviews reveal that advantages of MR for learning are seen in the highly realistic presentation of information that otherwise is not accessible, for instance, when visualizing potentially dangerous situations (e.g., flight simulations and machines in areas with chemicals). Moreover, MR allows presenting relevant augmented and realistic information side by side. This integration of information sources allows for information processing while learning. Further, specifically spatial information can be presented highly realistically. This might be especially helpful for learners with less prior knowledge and less spatial abilities, as such learner prerequisites might be compensated by MR. MR learning environments also allow for new kinds of direct interactions with the learning content, which might support the processing of information and the integration of new knowledge in preexisting mental models of the learners, due to realistic manipulations which increase embodied experiences. Last but not least, MR environments are expected to generate a feeling of high immersion in the learning environment, which increases the motivation to engage oneself in learning. All these advantages are combined with the challenge of orienting and processing highly complex environments. Nevertheless, empirical studies reveal mixed results for learning and motivation in MR environments. At this, it is of high interest to generate empirically proven guidelines for the creation of MR for learning. Besides the question of support of human information processing, such guidelines and design recommendations should explicitly take into account the affordances of generative learning processes.

A good instance showing the necessity to take higher learning processes into account in the development and design of educational MR technologies are navigation systems: While navigation systems support spatial information processing, their affordances do not promote the acquisition of spatial knowledge since they are designed to anticipate mental processes and not to foster the acquisition of knowledge (Adler, 2001; Münzer et al., 2012). The anticipation of mental processes by media is also called *supplantation* and is critically reflected in terms of its potentials to foster a deeper understanding of digital materials (Höffler & Leutner, 2007; Salomon, 2012; Schnotz & Bannert, 2003).

An essential part of MR technologies in general and its usage in learning environments in particular is the design of the user interface (UI). UIs are composed of the interactions, the input devices, and the sensory stimuli, that support human–machine interaction. When different sensory stimuli are generated simultaneously, interfaces are known as multimodal. In the past years, guidelines for the general design for UIs for MR-based tools have been published (LaViola et al., 2017; Pangilinan et al., 2019). However,

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